# Trinity Guardrail Terminal Performance Evaluation From 2013 U.S. National Automotive Sampling System (NASS) Cases

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Recently there has been considerable attention brought to bear on the performance of the energy-absorbing, guardrail terminals manufactured by Trinity Highway Products of Dallas Texas. The president of SPIG Industries of Bristol Virginia, Joshua Harman, a competitor or Trinity, filed a law suit against Trinity, claiming that Trinity had resigned its ET Plus guardrail in such a way that it began harpooning striking vehicles. It was further alleged that Trinity did not inform the U.S. Federal Highway Administration (FHWA) of this redesign and therefore the FHWA continued to approve the installation of the ET Plus throughout American highways.

Trinity is a globally dominant producer of guardrail systems. Its earlier product, the ET-2000, was functioning well in the field. Trinity was required to perform tests of the performance of its terminals according to the guidelines of the National Cooperative Highway Research Program (NCHRP) Report No. 350 and submit the results of the testing to the FHWA for approval. However, in about 2002 to 2005 it is alleged that the ET-2000 was redesigned to the current ET-Plus system without proper notification to the FHWA. The primary issue was with respect to the width of a channel of the ET-Plus terminal on the end of the guardrail through which the "W" rail is supposed to pass when the terminal plate is struck and displaced toward that rail. The original ET-2000 channel was 5 inches wide thus allowing easier motion of the rail through that wider channel. However, in Trinity's redesign it is alleged that the channel's width was reduced from 5 inches to 4 inches, effectively reducing the gap within which the rail could pass. This reduced gap caused the rail to become jammed within the channel creating a "harpoon" end point that would pierce through a striking vehicle.

Part of the evidence against the Trinity ET-Plus terminals involved research ("In-Service Evaluation of EHWA-Accepted Guardrail Terminals", 2014) by the University of Alabama at Birmingham (UAB), authored by Kevin Schrum which compared the injury-producing probabilities of several guardrail terminals in the field. As the ET-2000 and ET-Plus were the predominant installations, the research essentially compared the performance of these two terminals. The research found that the ET-Plus "...placed motorists at a higher level of risk of both serious injury and fatality relative to its predecessor, the ET-2000". That conclusion was drawn from examining the collision records of the states of Ohio and Missouri. It would seem reasonable that agencies such as the U.S. Federal Highway Administration (FHWA) should have completed similar analysis with data from all 50 states since the FHWA is the gatekeeper whose

responsibility is to determine which installations are safe. Yet, to date, no such analysis has been revealed.

In October, 2014 Trinity Highway Products was found liable by a U.S. federal jury with defrauding the U.S. government as a result of the modifications it made to the ET-Plus unit. This creates a potentially massive problem. It is estimated that there are in the neighbourhood of 500,000 installations of ET-Plus terminals in the U.S. alone. Canada's highways are also equipped with a large number of them. If these installations are deemed to be defective this could create an enormous cost to all those jurisdictions that followed federal instructions to install them. As the federal agencies did not detect the problem questions should naturally be raised why this detection did not occur. In the process of protecting their actions there is an obvious concern that the federal agencies such as the FHWA would attempt to demonstrate that there was nothing wrong with the installations, regardless of what the actual case may be. Subsequent to the trial the FHWA has asked Trinity to retest the ET-Plus unit to confirm that it meets the requirements of the NCHRP 350 guidelines.

However, clearly, the results of several tests under controlled conditions should not be the only and deciding factor whether the ET-Plus should continue to be installed on North American highways. It is the in-service performance of those units, in the field, that needs to be determined. The collision data from all 50 states needs to be gathered and evaluated under similar procedures as the UAB study authored by Kevin Schrum. It remains unexplainable why such research has apparently never been done.

In the absence of the essential research there are less effective ways of obtaining additional information about the in-service performance of ET-Plus terminals. For example, the U.S. National Highway Traffic Safety Administration (NHTSA) also has a variety of programs in place that collect data on real-life collisions. For example, the National Automotive Sampling System (NASS) has been collecting data on real-life collisions since 1979 and its database contains well over 140,000 incidents. The database collects information about the injuries sustained by vehicle occupants, the source of those injuries, and also contains detailed photographs of the collision sites and involved vehicles. Because the database originates from a random sampling of collisions it can be used to extrapolate to the population of collisions in the U.S. as a whole.

Unfortunately NASS has suffered in recent years from cuts in it research program. Its initial program contained 50 sampling centres, essentially one for every state. That number has been cut back drastically. The quality of the investigations has also notably suffered when one scans individual case files and it is noted that investigations are delayed while critical information is lost. Despite these shortcomings, NASS remains the only database that can be assessed by any independent agency, unlike state collision data which remains less accessible.

Because of our familiarity with the NASS procedures we decided to explore a segment of these cases to determine whether the collected data could provide useful information about the performance of the ET-Plus terminals. Due to our limited resources we were unable to study the full list of potential cases so some limitations on our study had to be imposed.

We selected collisions that occurred in 2013. The event had to involve a single passenger car, thus it could not involve the impact of a second vehicle. This excluded derivatives of cars such as any SUVs, pick-up trucks and vans. These restrictions resulted in the finding of 630 collisions. The individual data files were examined to select only those that involved the impact of a passenger car with a guardrail end terminal.

These restrictions resulted in finding only 11 collisions in the year 2013 where a passenger car struck a guardrail end terminal. It needs to be repeated that this is not the total of such collisions that occurred in the U.S., it is only the number of cases that were retrieved via the NASS investigators' sampling procedures . Thus, by knowing the sampling rate (i.e. 1 in every 50 collisions for that sampling unit and its stratum) one could extrapolate this data to estimate how many such collisions might have occurred in the U.S. in the year 2013.

Some of the details of these 11events are summarized in Table 1.

The third column of Table 1 indicates the type of guardrail terminal that was identified in the site photographs accompanying the file. In the fourth column we indicate whether the site photographs show the situation when the terminal is still damaged or whether the photographs were taken after the damage was already repaired. Thus it can be seen that in 7 of the 11 cases the site photos were taken after the guardrail and terminal were already repaired ("no, repaired").

This is not helpful as it is not possible to evaluate the status of the barrier to consider whether it had performed properly. In addition, the photos showing the repaired guardrail and terminal cannot be used to determine what kind of terminal was in place at the time of the collision. For example, it is conceivable that an ET-2000 might have been present when the impact occurred however, when the repair was made it could have been substituted by an ET-Plus terminal. Thus the site photos show the ET-Plus terminal however it might not be the actual terminal type that was struck.

One of the advantages of the NASS files has been the ability to examine the damage to the vehicle, the injuries sustained to the vehicle occupants, and to examine the source of the noted injuries. Again, the NASS files in Table 1 were also somewhat lacking in the quality of their injury information, as shown in the last column (Maximum Injury). In a number of instances the only available injury information was obtained from general comments made in police reports, instead of the more detailed hospital records.

We will now select a few of these cases and take a closer look at the file contents.

## Table 1:

**Summary of 2013 NASS Cases Involving Guardrail Terminal Impacts**

| Incident # | NASS Case # | Terminal Type | Terminal Damage Visible or Repaired? | Vehicle Type | Maximum Injury |
|---|---|---|---|---|---|
| 1 | 2013-08-079 | Wrapped Rail End | Yes, Deformation at terminal only | 2009 Honda Civic | Unknown |
| 2 | 2013-41-066 | ET-Plus | No, Repaired | 2003 Lexus | Incapacitating |
| 3 | 2013-43-089 | ET-Plus | No, Repaired | 2011 Nissan Murano | minor |
| 4 | 2013-48-045 | ET-Plus | Yes, Major Deformation | 2002 Chevrolet Monte Carlo | Incapacitating |
| 5 | 2013-49-075 | ET-2000 (possibly) | No, Repaired | 2000 Ford | Incapacitating |
| 6 | 2013-75-018 | Barrel-type Attachment to | Yes, moderate deformation | 2010 Toyota Corolla | Possible injury, severity unknown |
| 7 | 2013-75-094 | ET-2000 | No, Repaired | 2012 Ford Focus | Severe, coma |
| 8 | 2013-76-034 | ET-Plus | No, Repaired | 2007 Ford | Minor |
| 9 | 2013-76-114 | ET-Plus | No, Repaired | 2008 Honda Civic | Police report no injuries |
| 10 | 2013-79-103 | Wrapped Rail End | No, Repaired | 2009 Cadillac CTS | foot fracture |
| 11 | 2013-81-119 | Wrapped Rail End | Yes, moderate deformation | 2013 Nissan Leaf | Minor burn from air bag gases |

## Incident #1 - NASS Case # 2013-08-079

The NASS case summary indicated the following:

*"V1 was traveling north on a two lane undivided roadway when it departed the roadway to the right and contacted a guardrail end with its front. V1 then rotated clockwise contacting the guardrail face with its front. V1 while still rotating clockwise contacted the guardrail face with its left side."*

Figure 1 is a site drawing created by the NASS investigators to provide a general indication of how the collision transpired. It shows that, upon impact the case vehicle rotated clockwise and came to rest very close to the area of impact.

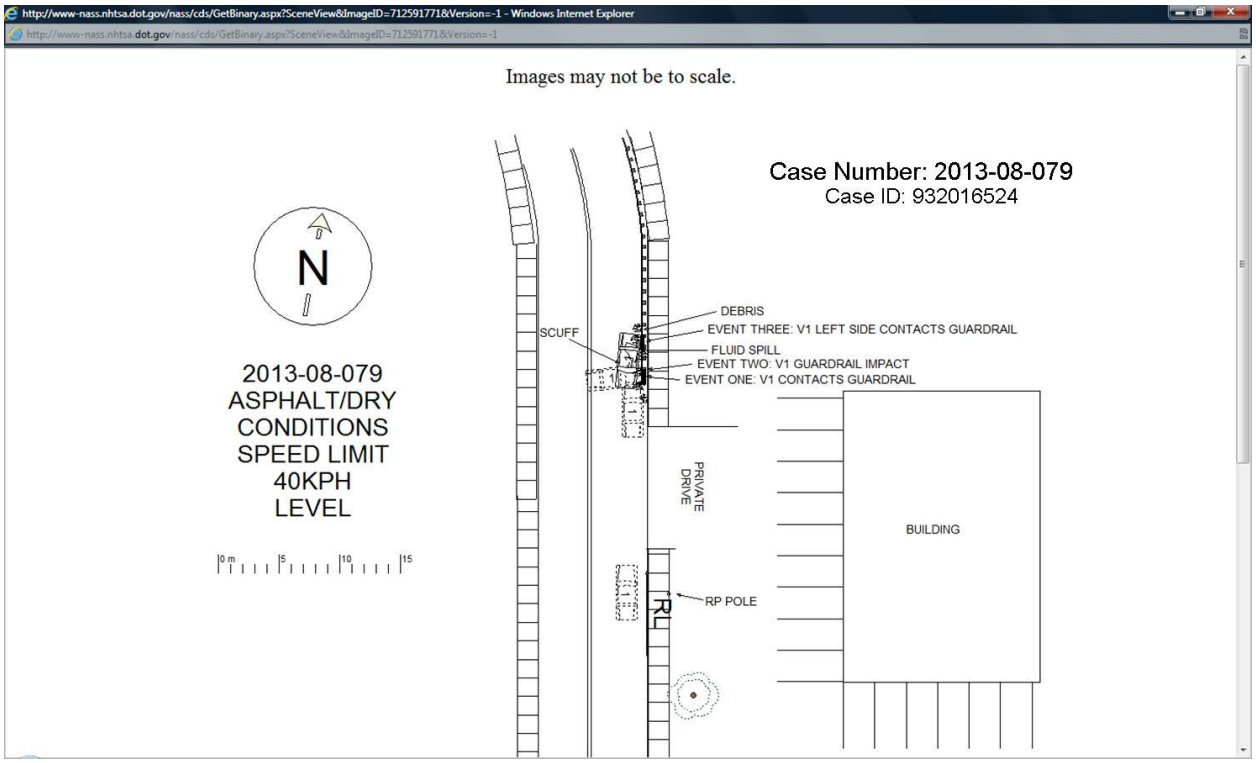


**Figure 1: Site diagram produced by the NASS investigators.**

General information about the involved vehicle indicated the following:

***General Vehicle 1 - Vehicle***

| | |
|---|---|
| ***Vehicle Number*** | *1* |
| ***Model Year*** | *2009* |
| ***Make*** | *HONDA* |
| ***Model*** | *CIVIC/CRX/DEL SOL* |
| ***VIN*** | *2HGFA16589* |
| ***Body Category*** | *Automobiles* |
| ***Body Type*** | *4-door sedan, hardtop* |
| ***Transport Status*** | *In transport* |
| ***Veh Special Use*** | *No Special Use* |
| ***Inspection*** | *Complete Inspection* |
| ***Inspection Interval*** | *0 days* |
| ***Curb Weight*** | *1199 kgs* |
| ***Curb Weight Source*** | *Canadian Specifications* |
| ***Cargo Weight*** | *0 kgs* |
| ***Cargo Weight Source*** | *Vehicle inspection* |

It is interesting to note that the "Inspection Interval", or delay in inspection, was "0 days" and this is an exceptionally short delay compared to other NASS cases where the delay is often substantial. The result is that the damage to the guardrail was able to be documented. Figure 2 shows a view of that damaged guardrail. This installation was not one of those manufactured by Trinity. The damage suggests that this was a rather low-severity impact.

**Figure 2: View of damaged end of guardrail.**

Figure 3 shows a front view of the damaged vehicle. The contact damage exists at the extreme right edge of the front end. This is more-clearly visualized in the right front view of Figure 4.

Although the vehicle damage appears to be relatively minor, there has been interaction with the right front wheel as evidenced by that wheel's extreme, outward angle. Contact to the stiffer wheel area would normally result in a higher collision severity than if there had only been side-swiping damage along the right side. Unfortunately there is no information about the injuries to the driver so the performance of the barrier system cannot be fully assessed.

We included this case in our discussions because it illustrates the limited usefulness of the NASS system when important information is missing. Also, it provides some general

information about the extent of damage to a non-Trinity guardrail system and the severity of damage that could be expected to the vehicle.

Figure 3: Front View of 2009 Honda Civic.

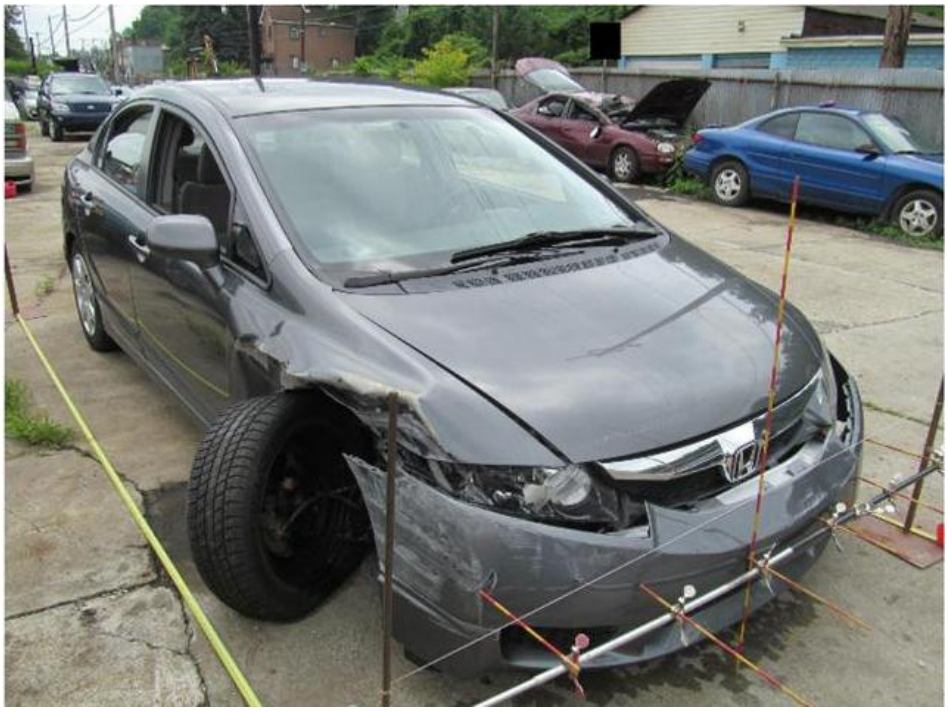

Figure 4: Right front view of Honda Civic.

## Incident #2 - NASS Case # 2013-41-066

The NASS case summary indicated the following:

*"V1 was traveling southbound in lane one of an interstate roadway. The driver lost control of the vehicle. V1 began to rotate in a clockwise direction as it traveled off the right side of the road. The left side of V1 made contact with the end of a guardrail. V1 then rolled onto its rooftop."*

Figure 5 is a site drawing created by the NASS investigators to provide a general indication of how the collision transpired. It shows that, upon impact the case vehicle rotated clockwise and then rolled over behind the guardrail.

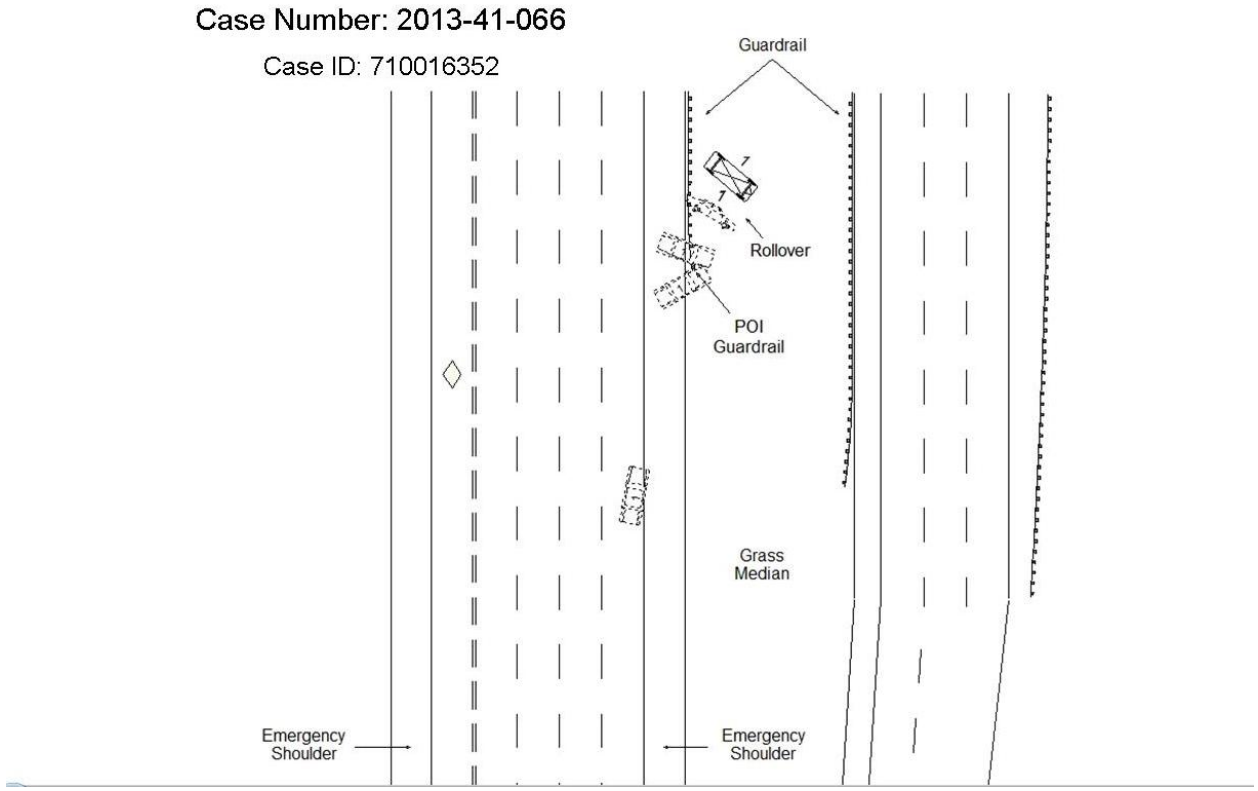


Figure 5: Site diagram created by the NASS investigators

General information about the impacting vehicle, a 2003 Lexus, is shown below. With respect to the vehicle's inspection we see the comment "Partial Inspection - MY Greater than 10 years". It would appear that a policy has been established whereby older vehicles do not receive the detailed inspection that would normally take place under the NASS program and this is the reason for the observed coding.

**Vehicle 1 Exterior - Vehicle**

| | |
|---|---|
| **Vehicle Number** | 1 |
| **Model Year** | 2003 |
| **Make** | LEXUS |
| **Model** | ES-250/300/330/350 |
| **VIN** | JTHBF30G33 |
| **Body Type** | 4-door sedan, hardtop |
| **Transport Status** | In transport |
| **Veh Special Use** | No Special Use |
| **Inspection** | Partial Inspection - MY Greater than 10 years |
| **Inspection Interval** | 43 days |
| **Curb Weight** | 1560 kgs |
| **Curb Weight Source** | Canadian Specifications |
| **Cargo Weight** | 0 kgs |
| **Cargo Weight Source** | Vehicle inspection |

Another interesting code for "Inspection Interval" is "43 days". This is the delay between the date of the collision and the commencement of the investigation. In the previous case we saw this coded as "0 Days" meaning that there was very little delay in commencement of the investigation.

A delay of 43 days is quite substantial and it would normally lead to a loss of valuable information and evidence. This loss of information is exemplified by the site photographs, such as Figures 6, 7 and 8.

Figure 6: View, looking toward the repaired guardrail that contains a Trinity ET-Plus end terminal.

**Figure 7: View looking back from the rest position of the striking vehicle toward the area of impact at the ET-Plus end terminal.**

**Figure 8: View looking from the area of impact toward the rest position of the striking vehicle.**

The site photographs show that the guardrail has already been repaired and there is little evidence on the ground to determine how the striking vehicle moved from impact to its rest position. This is the result of the 43 days delay in commencing the investigation.

As mentioned earlier, although the site photos show that an ET-Plus end terminal is installed at the end of the guardrail, that does not mean that the same kind of terminal existed at the time of impact. If photographs had been taken while the guardrail was still in its damaged state there would not be this ambiguity.

Despite the lack of information at the collision site, NASS investigators were able to examine the impacting vehicle. Figure 9 shows a left front view of the Lexus.

Figure 9: Left front view of 2003 Lexus.

There is a clear imprint just above the left-front wheel that appears to have dimensions similar to the ET-Plus terminal. Therefore, the damage on the vehicle may suggest that the it was an ET-Plus terminal that was installed at the end of the guardrail at the time of this impact.

Figure 10 shows a left rear view of the Lexus and Figure 11 shows the right side of the vehicle. The damage evidence leaves one to question how the interaction occurred between the guardrail and vehicle as there is some unusual damage on the vehicle.

Figure 10: Left rear view of 2003 Lexus.

Figure 11: View of right side of Lexus.

Figure 12 shows the interior of the Lexus.

Figure 12: View of interior of Lexus.

As concern has been expressed  with respect to the jamming of the guardrail within the ET-Plus terminal resulting in harpooning of the vehicle by the rail, there appears to be sufficient evidence in the photographs of the vehicle to question whether such harpooning occurred in this instance. There appears to be a linear object lying within the interior of the vehicle and this leads to the question whether this is part of the guardrail and terminal system that entered into the interior during the impact. If there was no opening of the vehicle to the exterior then we would be less inclined to believe that such harpooning occurred. However, the photos show that there appears to be an opening at the left rear door, such that the door appears to be removed. The view of the right side shows that the right front door is removed and a damaged door appears to be lying loose on the right front seat. The damage to this door is not typical of what one would expect from a low-speed rollover and it suggests that the damage was caused during the interaction with the guardrail. Further information is needed to determine if the ET-Plus terminal failed to perform properly however the available evidence suspiciously tends toward that conclusion.

Normally, the NASS file could contain detailed information about the occupants of the vehicle as well as their injuries. In the present case, there is some information about the driver of the Lexus, as noted below.

**Vehicle 1 Occupant 1 - Profile**

| | |
|---|---|
| **Age** | 66 Years |
| **Height** | Unknown |
| **Weight** | Unknown |
| **Sex** | Male |
| **Fetal Mortality** | Not applicable |
| **Role** | Driver |
| **Race** | Unknown |
| **Ethnicity** | Unknown |
| **Eye Wear** | Unknown |
| **Child Seat** | No |
| **Police Reported Air Bag Avail / Function** | Not deployed |
| **Police Reported Belt Use** | Lap and shoulder belt |
| **Police Accident Report KABCOU** | A - Incapacitating injury |

However, all we know is that the 66-year-old male driver sustained an "Incapacitating Injury". Such a description is insufficient. We cannot tell what the specific injury was and whether it could be related to a possible malfunction of the ET-Plus terminal.

## Incident #4 - NASS Case # 2013-48-045

The NASS case summary indicated the following:

*"Vehicle #1 was traveling south on a major highway and departed the road to the right onto the downslope of a shallow grass ditch. The front contacted a light pole and then a guard rail end with the front plane."*

Figure 13 is a site drawing created by the NASS investigators to provide a general indication of how the collision transpired.  It shows that the vehicle exited the right side of the road struck a lamp pole and the collided with the end of the guardrail.

Figure 14 shows a view of the right side of the highway and we can see tire marks in the grass. The tire marks pass through the area of a fallen light pole and then we can see in the background that a temporary, orange barrier has been set up at the location where the vehicle struck the end of the guardrail.

Figures 15 through 19 provide closer views of the damage to the guardrail.

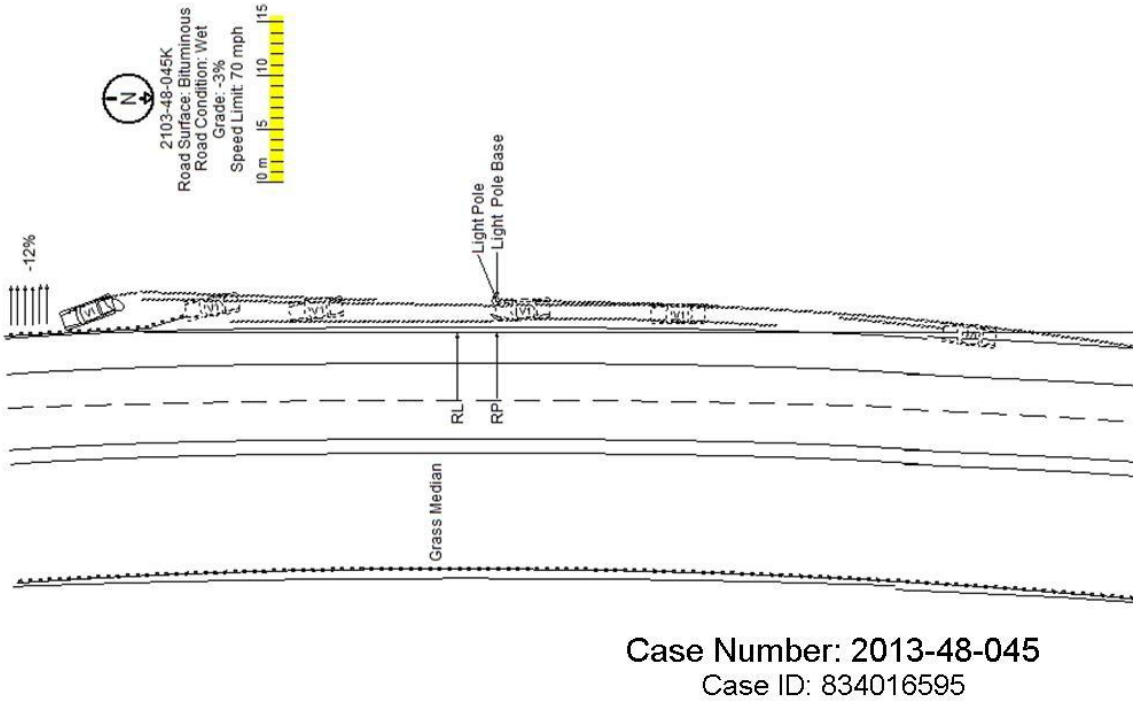


**Figure 13: Site Diagram drawn by NASS investigators.**

**Figure 14: View looking toward the struck guardrail with the damaged light pole in the foreground.**

**Figure 15: View or temporary, orange barrier in the foreground and the damaged guardrail in the background.**

**Figure 16: View of the orange, temporary barrier and the parts of the damaged guardrail.**

**Figure 17: View of the Trinity ET-Plus end terminal that is lying to the right, separated from the rest of the "w" rail.**

**Figure 18: View looking back in the direction of the vehicle's approach. The diagonal striped orange and black face of the ET-Plus terminal is visible separated from the rest of the guardrail.**

Figure 19: View of the backside of the guardrail showing the separated ET-Plus end terminal in the upper left of the photo.

The guardrail photos suggest a combination of damage from the impact and possible post-impact work by road maintenance personnel. The post-impact work appears to be the cutting of the damaged "w" rail as the separation appears to be too uniform to have been caused by the collision. There was no indication in the case file that explained how the guardrail damage visible in the photos was caused.

Sections of the guardrail have been flattened indicating that they passed through the end terminal which is designed to flatten the railing as a means of absorbing the collision energy. The rail's deformation and flattening are important and desirable safety features provided that it occurs in a controlled manner and does not pierce into the interior of a vehicle. Thus the system needs to be designed in such a way that deformation occurs progressively over an extended time creating a relatively constant level of negative acceleration (deceleration) of the striking vehicle.

General information about the damaged vehicle is noted below.

Again, when we look at the "Inspection Interval" code we note "0 days" indicating that the investigation was commenced on the same day as the collision and this is confirmed by the fresh evidence that we see at the collision site. The form also indicates that a "Partial Inspection" occurred because the vehicle was more than 10 years old.

## General Vehicle 1 - Vehicle

| | |
|---|---|
| **Vehicle Number** | 1 |
| **Model Year** | 2002 |
| **Make** | CHEVROLET |
| **Model** | MONTE CARLO (1995+) (FWD ONLY) |
| **VIN** | 2G1WX15KX2 |
| **Body Category** | Automobiles |
| **Body Type** | 2-door sedan, hardtop, coupe |
| **Transport Status** | In transport |
| **Veh Special Use** | No Special Use |
| **Inspection** | Partial Inspection - MY Greater than 10 years |
| **Inspection Interval** | 0 days |
| **Curb Weight** | 1527 kgs |
| **Curb Weight Source** | Automotive News |
| **Cargo Weight** | 0 kgs |
| **Cargo Weight Source** | Vehicle inspection |

Figure 20 shows a frontal view of the 2002 Chevrolet Monte Carlo that was involved in this impact. There are two diagonal creases the front edge of the hood which delineate the location where the Trinity ET-Plus end terminal made contact.

Figure 20: Front view of Monte Carlo.

Figures 21 and 22 show that there is no other significant, direct contact damage to the sides of the vehicle.

**Figure 21: Left front view of Monte Carlo.**

**Figure 22: Right front view of Monte Carlo.**

Figure 23 shows that there is minor damage to the rear of the vehicle as the cover to the rear bumper has been torn off. This would not be a threat to the safety of the vehicle occupants.

**Figure 23: Left rear view of Monte Carlo.**

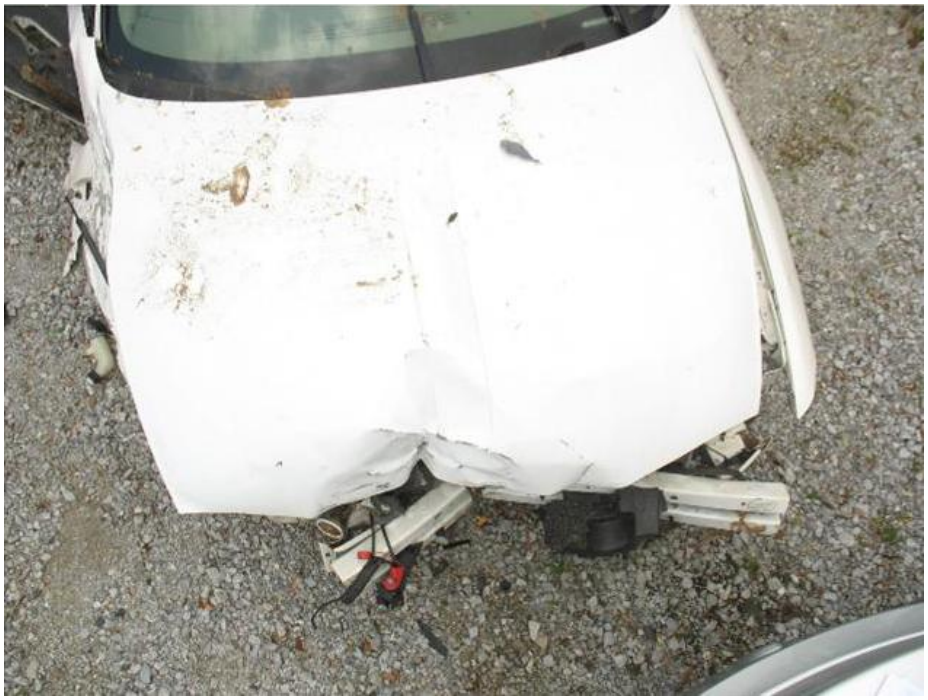

**Figure 24: Top view of Monte Carlo.**

The top view in Figure 24 shows the notch in the front edge of the hood which came from contact by the end plate of the ET-Plus terminal. However the damage is confined to the front end and there is essentially no deformation at the rear of the hood and windshield area. Thus this could be classified as a fairly innocuous, moderate severity impact.

NASS investigators have a specialized procedure for documenting vehicle damage and crush and this is shown in the form below.

**Vehicle 1 Exterior - Crush - Profile 2**

| | |
|---|---|
| **Profile No** | 2 |
| **Event Number** | 2 |
| **CDC** | 12FDEW02 |
| **Direct Damage Location** | begin RF BC |
| **Field L Location** | BC to BC |
| **Max Crush Location** | 7cm right of C4 |
| **Width CDC** | 97 |
| **Category** | End |

| | | | |
|---|---|---|---|
| **Field L** | 114 cms | **Field L D** | 0 cms |
| **SMASH L** | 154 cms | **Direct D** | 8 cms |

| **Measurements (in centimeters)** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Sign** | **Plane Cat** | **Max** | **C1** | **C2** | **C3** | **C4** | **C5** | **C6** |
| + | Bumper | 44 | 20 | 27 | 34 | 42 | 24 | 22 |
| - | Free Space | 0 | 9 | 4 | 1 | 1 | 4 | 9 |
| - | Free Space | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| = | Result | 32 | 0 | 11 | 21 | 29 | 8 | 1 |
| **Finalized Profile** | | | | | | | | |
| | | 32 | 0 | 11 | 21 | 29 | 8 | 1 |

One of the items in the above form is a Collision Deformation Classification (CDC) which is a set of letters and numbers used to describe the visible damage. The CDC for this damage is "12FDEW02" . The last two digits "02" indicate the severity of the damage by dividing the longitudinal distance between the front bumper and base of the windshield into 5 zones. Thus the "02" means that the front end crush on this vehicle extended into the 2nd of the 5 zones.

Further down in the form the NASS investigators report on the specific crush measurements then taken from a base-line that they created at the original position of the front bumper. Thus the width of 114 centimetres was used within which six, equi-distant crush measurements (C1 to C6) were taken. The "Max" value is the maximum crush that is often not located at any of the six crush measurements and this is noted as 32 centimetres. Using these procedures NASS investigators us a computer algorithm

which calculates the collision severity or change-in-velocity, which is sometimes referred to as the Delta-V. Generally, Delta-V is proportional to injury severity such that as the Delta-V becomes higher there is a higher likelihood of sustaining higher severities of injury.

The forms below report on the characteristics of the three occupants in this collision.

### Vehicle 1 Occupant 1 - Profile

| | |
|---|---|
| **Age** | 19 Years |
| **Height** | Unknown |
| **Weight** | Unknown |
| **Sex** | Female |
| **Fetal Mortality** | Not applicable |
| **Role** | Driver |
| **Race** | Black or African American |
| **Ethnicity** | Unknown |
| **Eye Wear** | Unknown |
| **Child Seat** | No |
| **Police Reported Air Bag Avail / Function** | Deployed |
| **Police Reported Belt Use** | Lap and shoulder belt |
| **Police Accident Report KABCOU** | C - Possible injury |

### Vehicle 1 Occupant 2 - Profile

| | |
|---|---|
| **Age** | 23 Years |
| **Height** | Unknown |
| **Weight** | Unknown |
| **Sex** | Male |
| **Fetal Mortality** | Not applicable |
| **Role** | Passenger |
| **Race** | Unknown |
| **Ethnicity** | Unknown |
| **Eye Wear** | Unknown |
| **Child Seat** | No |
| **Police Reported Air Bag Avail / Function** | Deployed |
| **Police Reported Belt Use** | None Used |
| **Police Accident Report KABCOU** | A - Incapacitating injury |

### Vehicle 1 Occupant 3 - Profile

| | |
|---|---|
| **Age** | 20 Years |
| **Height** | Unknown |

| | |
|---|---|
| **Weight** | Unknown |
| **Sex** | Male |
| **Fetal Mortality** | Not applicable |
| **Role** | Passenger |
| **Race** | Unknown |
| **Ethnicity** | Unknown |
| **Eye Wear** | Unknown |
| **Child Seat** | No |
| **Police Reported Air Bag Avail / Function** | No air bag available |
| **Police Reported Belt Use** | None Used |
| **Police Accident Report KABCOU** | O - No injury |

Unfortunately there is no detailed information on the injuries sustained by these occupants. All that remains is the injury description provided in the police report. We see that Occupant 1 sustained a "Possible Injury", Occupant 2 sustained an "Incapacitating Injury" and Occupant 3 was not injured.

We would be curious to understand why Occupant 2 sustained the "Incapacitating Injury" however the form indicates that Occupant 2 was not wearing a seat belt and this could be the explanation.

## Discussion

A brief assessment has been carried out of the U.S. National Automotive Sampling System (NASS) case files to determine whether their content can shed some light on the field performance of the ET-Plus guardrail end terminal produced by Trinity Highway Products of Dallas Texas.

A selection of 630 single vehicle collisions from the 2013 sampling year were screened to select those involving impacts to guardrail ends by passenger cars. Eleven such incidents were found. In 7 of those 11 the guardrails were already repaired by the time NASS investigators attended the accident site. It was clear that in many instances the attendance of these sites involved long delays and therefore valuable information was lost. It was also evident that much of the detailed medical information that has been previously associated with NASS files was missing. It is suspected that these problems relate to the reduction of resources available to the NASS system.

Despite these shortcomings the NASS program has the potential of providing very good information that could guide researchers toward understanding the safety effectiveness of non-vehicle factors such as highway roadside objects like guardrails and their end terminals. Although state data files might be more complete in terms of documenting every collision on the highway those files suffer from a lack of quality inspection of

evidence related to the vehicle and the detailed medical data that is needed to discriminate between safe and less safe roadsides.

Although only three cases were examined in detail, this study has found that one of those cases likely resulted in an unusual interaction between an ET-Plus terminal and the striking vehicle. Certainly much more work would need to be done, involving examination of many more cases before conclusions could be drawn from that occurrence.

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